THE WING VENATION OF THE FULGORIDÆ.

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The present paper is a continuation of my work on the homologies of the wing veins of Homopterous insects, a paper having previously been published on the wing venation of the Jassidæ.*

The present paper is based upon a study of the wing pads of eleven genera of Fulgoridæ. These eleven genera are distributed among seven of the eleven commonly recognized sub-families of Fulgoridæ. Two of the sub-families not represented in this study are not found in our territory and I have not been able to secure representatives of the two remaining sub-families, *Achilida* and *Fulgorida*. The venation of these two sub-families presents no special difficulties when viewed in the light of our knowledge of other Fulgoridæ which have been carefully studied.

The same technique has been used in preparing the material for studying the wing venation of the Fulgoridæ that was used for studying the Jassidæ. The nymphal wings being removed as carefully as possible were mounted in water. The wing pad was then either drawn with the aid of a camera lucida or a photomicrograph made. Afterward a pen and ink drawing was made from the photomicrograph uniform with the camera lucida drawings. The drawings of the adult wings were made from balsam mounts with the aid of the Edinger drawing apparatus. The magnifications used in both cases varied greatly being adapted as far as possible to the needs of individual cases.

The relation of the main tracheæ of the wing pads to the body tracheæ is an interesting one and one upon which much stress has been laid in the past. The relationships of the main tracheæ of the wing pads can be much better understood if they can be traced back to their origin from the main body tracheæ.

Unfortunately, however, the wing pads of most insects are so placed that the body tracheæ lie very deep. This makes it practically impossible to secure the body tracheæ by the

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ordinary methods of dissection. If the wing is carefully removed, however, the relationships of the main tracheæ need not be disturbed. Some emphasis has also been placed on the fact that in some families the tracheæ of the wing pads arise from a single basal trachea, whereas in certain other families the radio-medial group of tracheæ arises from a cephalic body trachea while the cubito-anal group arises from a caudal body trachea. In certain cases this character has been used to indicate that one family is more primitive structurally than another. That such a position is untenable is clearly shown in at least two genera of the Fulgoridæ in which I was so fortunate as to secure enough of the body tracheæ as to determine this point. In *Thionia* (Figs. 27, 28) the tracheæ of the fore wing pad arise from a single body trachea while the tracheæ of the hind wing pad arise from a cephalic and a caudal body trachea. In *Amphiscepa* (Figs. 5, 6), on the other hand, the tracheæ of the fore wing arise from two body tracheæ whereas the tracheæ of the hind wing arise from a single body trachea.

THE FORE WING.

Unlike the fore wings of the Jassidæ, the fore wings of the Fulgoridæ are exceedingly variable. As is well known, the adults of many Fulgoridæ occur in two forms, a long-winged or *macropterous form*, and a short-winged or *brachypterous form*. This is especially true of certain genera. While the problem of the origin and significance of this variation is an exceedingly interesting one, it has not been taken into consideration in this paper, and as a rule, only *macropterous forms* have been considered with the exception of a few cases where the *brachypterous forms* are the usual ones.

The wings of the Fulgoridæ show two marked forms of specialization from the hypothetical type, the one by the addition of accessory branches to the main veins and the other by the reduction of the number of branches of the main veins. The one may be known as specialization by addition, and the other as specialization by reduction. An almost perfect series can be traced from the one extreme to the other. Forms like *Ormenis* (Fig. 13), show as great specialization by addition as is found in any insect of any order, while forms like *Bruchomorpha* (Fig. 33), show a great deal of specialization by re-

duction. While the wing venation of most of the insects that have been studied extensively so far can be reduced to a more or less uniform type for the family, in the Fulgoridæ no such typical form can be given. In the following discussion of the individual tracheæ the differences in the characters of the same trachea in different genera will not be emphasized so much as their resemblances.

The Costa of the Fore Wing.

The costa of the fore wing is usually present in the Fulgoridæ, in fact it was found in practically every genus studied. Typically, costa is a single unbranched trachea usually of somewhat less extent than subcosta. In *Ormenis* (Fig. 3), however, there are many small lateral tracheæ formed along the entire length of the costal trachea, and in *Amphiscepa* (Fig 5), the tip of the costal trachea breaks up into several smaller tracheæ. In *Thionia* (Fig. 27), the costal trachea shows a strong lateral branch near its base. This branch runs parallel with the main branch of costa and seems to be included in the same forming vein.

The Subcosta of the Fore Wing.

The subcosta has been found present in all of the genera studied. In many of the genera subcosta is a larger and more important trachea than radius. In nearly all cases it lies parallel with radius for the greater part of its length, while in *Scolops* (Fig. 23), it lies parallel with radius for its entire length. Subcosta is typically two branched in the *Delphacida* (Figs. 43, 45), and in the *Cixiida* (Fig. 47), while in *Amphiscepa* (Fig. 5), and *Ormenis* (Fig. 3), the tip of the subcosta breaks up into several small tracheæ.

The Radius of the Fore Wing.

Radius in the Fulgoridæ occupies a much less important position than in the wings of most other insects which have been studied in detail up to the present time. In most cases the radial trachea lies parallel with the subcostal trachea and usually only a single vein is formed in the region occupied by these two tracheæ. In *Stobæra* (Fig. 45), radius is a single unbranched trachea lying parallel with subcosta for more than half of its length then diverging and running parallel with one of the branches of medius for a short distance it

diverges toward the costal border. Radius occupies a somewhat similar position in *Myndus* (Fig. 47), except that there are three or four small branches near the tip and the trachea does not coalesce with medius in any part of its course. The condition of the radial trachea in *Dictyophara* (Fig. 25), is almost identical with that in *Myndus*, except that there are small lateral branches toward the tip. In *Thionia* (Fig. 27) and *Scolops* (Fig. 23), the radial trachea is quite similar in appearance to that in the genera discussed above except that separate veins are formed along these two trachea in *Thionia*. In both of these genera the lateral branches near the tip are much weaker and more uncertain in their position and are not the fore-runners of typical and fairly constant longitudinal veins, but of rather uncertain cross veins which are fairly common in these genera. In *Amphiscepa* (Fig. 5), and *Acanalonia* (Fig. 1) radius is a single unbranched trachea. In *Ormenis* (Fig. 3), the radial trachea consists of two main tracheæ which separate into several smaller branches before reaching the tip.

The Medius of the Fore Wing.

In all the genera studied the medial trachea is the most important trachea of the fore wing and its branches occupy more area than the branches of any other trachea. In the genera studied medius seems to be typically four branched only in *Amphiscepa* (Fig. 5). Each one of these branches, however, branches one or more times before reaching the tip of the wing. In *Ormenis* (Fig. 3), medius divides into two branches each branch again dividing into two branches. Each of these branches, however, is several times divided before reaching the tip of the wing pad. In *Acanalonia* (Fig. 1), medius is three branched, these branches representing medius one, medius two and medius three plus four. In *Scolops* (Fig. 23), *Dictyophara* (Fig. 25) and *Thionia* (Fig. 27), medius is typically two branched, although these branches may divide one or more times before reaching the tip of the wing pad. The veins which form along these secondary branches are not at all constant in position and relative importance. In *Stobæra* (Fig. 45), medius divides into two main branches. These branches represent medius one plus two and medius three plus four, medius one and medius two separating before reach-

ing the tip of the wing pad. In *Myndus* (Fig. 47), medius is typically four branched with an accessory branch between medius one and medius two.

The Cubitus and the First Anal of the Fore Wing.

As in the Jassidæ the cubital-first anal group forms the most characteristic land-mark in the tracheation of the Fulgoridæ. These two trachea are united for a short distance from the body trachea and cubitus is usually two branched. In *Thionia* (Fig. 27), *Dictyophara* (Fig. 25) and *Acanalonia* (Fig. 1), cubitus is unbranched, while in *Phylloscelis* (Fig. 7), cubitus is two branched and in *Stobæra* (Fig. 45), there is an accessory branch between cubitus one and cubitus two.

The Second and Third Anal of the Fore Wing.

The second anal trachea is a simple unbranched trachea and usually lies parallel with the first anal trachea. The third anal trachea is nearly always present in Fulgoridæ and is usually two branched. The second branch when present usually forms the anal border of the fore wing.

THE HIND WING.

The hind wing of the Fulgoridæ is almost as variable as the fore wing, very little similarity being observed in the different genera of some of the sub-families. Quite a little variation is frequently observed in different individuals of the same species.

The Costa of the Hind Wing.

The costal trachea is present in the following widely separated genera: *Myndus* (Fig. 48), *Scolops* (Fig. 24), *Dictyophara* (Fig. 26), *Thionia* (Fig. 28), *Acanalonia* (Fig. 2), and *Phylloscelis* (Fig. 8). In *Thionia*, *Phylloscelis* and *Myndus* it is united with subcosta for some distance from the body trachea. In *Scolops* it is present only as a weak trachea at the base of the wing.

The Subcosta of the Hind Wing.

The subcostal trachea was found in all the wing pads studied. In most of the genera it runs parallel with radius for almost its entire length and diverges at the tip. The radial and subcostal tracheæ are included in a common vein

except at the tip where subcosta diverges and the vein which forms along this tip in the adult resembles a branch of the radial vein. This condition is especially apparent in *Stobæra* (Fig. 46), *Myndus* (Fig. 48), *Dictyophara* (Fig. 26) and *Amphiscepa* (Fig. 6). In *Scolops* (Fig. 24), subcosta appears merely as a weak trachea lying parallel with radius along its base.

The Radius of the Hind Wing.

In nearly all cases radius of the hind wing is a single unbranched trachea. In certain genera, however, such as *Scolops* (Fig. 24), *Dictyophara* (Fig. 26) and *Acanalonia* (Fig. 2), radius shows more or less tendency to branch near the tip. These branches are rather variable as an examination of different individuals of the same species clearly shows. Therefore I have made no attempt to homologize these branches.

The Medius of the Hind Wing.

A typical medius of the hind wing of Fulgoridæ is two branched, but frequently these branches show a decided tendency to branch again before reaching the tip of the wing pad. In *Stobæra* (Fig. 46) and *Thionia* (Fig. 28) medius is a simple unbranched trachea which in *Stobæra* runs parallel with cubitus for a considerable distance, the veins of the adult coalescing at this point.

The Cubitus of the Hind Wing.

In many genera cubitus of the hind wing occupies the greatest area and bears somewhat the same relationship to the other tracheæ of the hind wing that medius bears to the other tracheæ of the fore wing. In *Myndus* (Fig. 48) and *Phylloscelis* (Fig. 8), cubitus is unbranched. In *Stobæra* (Fig. 46), *Thionia* (Fig. 28) and *Scolops* (Fig. 24) cubitus is typical. In the other genera studied cubitus has two principal branches, each of which bears one or more accessory branches.

The Anals of the Hind Wing.

The first anal of the hind wing bears the same relation to cubitus that it does in the fore wing. The second anal trachea is usually simple and unbranched, and lies parallel with the first anal. The third anal trachea has been found in all of the genera studied and is usually branched. Although in some cases *Thionia*, *Dictyophara* and *Scolops* the third anal trachea is three branched.

SUMMARY.

Owing to the fact that the adult wings of the Fulgoridæ vary so much it has seemed best to summarize the homologies of adult wing veins by giving a discussion of the characters of the adult wings of the various subfamilies.

Sub-family **Fulgorida.**

Both the fore and hind wings of this sub-family are characterized by a large amount of reticulation. Nearly all the members of this sub-family are characterized by having a large number of accessory veins. These accessory veins may be added to radius, medius or cubitus, but in some cases, as in *Poiocera* (Fig. 9) all three of these veins bear accessory veins. In the hind wing radius and medius do not usually bear many accessory veins, but cubitus usually has several accessory veins. Another characteristic of the hind wings is the fact that the cross veins are apt to be connected together forming false veins between the principal veins. These false veins usually lie along the folds of the wing.

Sub-family **Flatida.**

The chief characteristics of this sub-family are: First, that the costal vein is remote from the costal border of the wing and connected with it by means of a number of cross veins; second, that radius and medius are provided with a large number of accessory veins; and third, that these accessory veins are usually connected by a definite series of cross veins at a uniform distance from the apical border of the wing. The hind wing is chiefly characterized by the great development of the anal area of the wing, and by a large number of accessory veins attached to cubitus.

Sub-family **Acanaloniida.**

The fore wings of the members of this sub-family are characterized by having a large number of cross veins between the branches of the principal veins. They are also characterized by having radius simple and unbranched, and the larger area of the wing occupied by the branches of the medius. In some cases, *Amphiscepa* (Fig. 15), medius is typically four branched with the addition of accessory veins to some of the branches. In other cases, *Acanalonia* (Fig. 17), medius is three branched,

the branches representing medius one, medius two and medius three plus four. The hind wing is characterized by the great development of cubitus, and the fact that in certain cases, *Amphiscepa* (Fig. 16), radius and medius coalesce for a considerable distance from the base of the wing.

Sub-family **Achilida.**

The fore wings in this sub-family are characterized by the fact that subcosta and radius are coalesced for a considerable distance from the base, and the fact that there are usually several cross veins between subcosta and the costal border of the wing. Radius and medius offer no special characters and cubitus is typically two branched, although there are frequently accessory cross veins between cubitus two and the anal border of the wing.

Sub-family **Dictyopharida.**

The chief characteristics of this sub-family are to be found in the complete or all but complete coalescence of subcosta and radius. In *Scolops* (Fig. 29), they are completely coalesced. In *Dictyophara* (Fig. 31), nearly completely coalesced, but in *Phylloscelis* (Fig. 22), are not coalesced except for a short distance at the base. Medius is typically two branched, but in *Scolops* (Fig. 29), there are several accessory branches. In *Scolops* (Fig. 29), and *Dictyophara* (Fig. 31), cubitus is typically two branched, but in *Phylloscelis* (Fig. 22), cubitus bears several accessory branches.

Sub-family **Issida.**

I have studied only a few genera in this sub-family. In *Thionia* (Fig. 35), all of the branches of the principal veins are reduced, medius alone being typically two branched. All of the veins are connected by a number of cross veins. In *Bruchomorpha* (Fig. 33), a study of the adult wing alone seems to indicate a condition closely approximating the condition found in the Delphacida, in which radius and medius are coalesced for a considerable distance, radius diverging strongly and coalescing with medius throughout the middle of its course, and then diverging strongly toward the costal border of the wing. In all of the Issida that I have examined second and third anal are coalesced for nearly half of their course at

the tip.   In *Thionia* (Fig. 36), the anal area of the hind wing is larger than the preanal area, and third anal is characterized by the addition of a large number of accessory veins.   In *Bruchomorpha* (Fig. 34), the hind wing is greatly reduced in area, and the principal veins only are represented by simple unbranched veins.

<div align="center">Sub-family Derbida.</div>

In this sub-family, also, subcosta and radius are coalesced for a considerable distance from the base, and both are typically two branched; although in some cases, *Otiocerus* (Fig. 39), there are a number of cross veins between subcosta and the costal border.   Medius is typically four branched with a number of accessory veins added to medius one.   In *Anotia* (Fig. 37), and *Otiocerus* (Fig. 39), there is an accessory vein between medius three and four.   In *Lamenia* (Fig. 41), there are no accessory veins between medius three and medius four, and only a single accessory vein between medius one and medius two.   Cubitus is typically two branched, but in *Otiocerus* and *Anotia* these branches do not extend to the anal border of the wing, but unite with the coalesced anals at some little distance from the border of the wing.   In the hind wings, subcosta and radius are coalesced, and medius is two branched in *Anotia* (Fig. 38) and *Otiocerus* (Fig. 40), but unbranched in *Lamenia* (Fig. 42).   Cubitus of the hind wing is two branched in all of the members of this sub-family which I have examined.

<div align="center">Sub-family Cixiida.</div>

This sub-family also is characterized by the fact that subcosta and radius are coalesced for some distance from the base.   Subcosta is typically two branched, although in *Bothriocera* (Fig. 60), *Oliarus* (Fig. 58) and *Œcleus* (Fig. 62) supernumerary veins are added between subcosta one and subcosta two.   Radius is typically three branched, although these branches are somewhat variable in their relationships.   Medius is typically four branched with an accessory vein between medius one and medius two, although in *Oliarus* (Fig. 58), both medius one and medius two bear accessory veins.   Cubitus of the fore wing is typically two branched, and second and third anals are coalesced at the tip.   In the hind wing subcosta and radius are coalesced for a considerable distance from the base,

and radius has two branches except in *Myndus* (Fig. 56). Medius is typically three branched except in *Œcleus* (Fig. 63), where it is only two branched. Cubitus is unbranched in *Myndus*, and two branched in all of the other members of this subfamily that I have examined.

Sub-family **Delphacida.**

In the fore wing, subcosta is typically two branched. Radius is coalesced with subcosta for about half of its length, when it diverges suddenly, then coalesces near the middle of its course with medius one plus two. It then diverges toward the costal border of the wing. Medius is typically three branched, the branches represented being medius one, medius two and medius three plus four. Medius three plus four frequently coalesces for a short distance with cubitus one, as in *Liburnia* (Fig. 53) and *Stenocranus* (Fig. 49). In *Stobæra* (Fig. 51), these two veins are connected by a short cross vein. Cubitus is three branched an accessory vein being developed along the anal side of cubitus one. In the hind wing, subcosta and radius are coalesced for more than half of their length and medius is unbranched. Cubitus is typically two branched, cubitus one coalescing for almost its entire length with medius, being separated only at its tip. The anal area of the hind wing is considerably enlarged and the third anal is frequently three branched.

REFERENCES.

Ashmead, W. H. 1889. A Generic Synopsis of the Fulgoridæ. Ent. Amer., V, 1–6 and 21–28.

Edwards, J. A. 1896. The Hemiptera Homoptera of the British Islands.

Melichar, L. 1896. Cicadinen von Mittel-Europa.

Melichar, L. 1898. Monographie der Ricaniiden.

Melichar, L. Monographie der Acanaloniiden und Flatiden.

Melichar, L. 1906. Monographie der Issiden.

Metcalf, Z. P. 1913. The Wing Venation of the Jassidæ. Ann. of the Ent. Soc. of Amer. VI, 103–115.

Osborn, H. 1903. A Subterranean Root-infesting Fulgorid. Ohio Nat. IV, 42–44.

Osborn, H. 1904. Note on Alate form of Phylloscelis. Ohio Nat. IV, 93–94.

Swezey, O. H. 1903. Life History Notes on Two Fulgoridæ. Ohio Nat. III, 354–357.

Swezey, O. H. 1904. A Preliminary Catalogue of the Described Species of the Family Fulgoridæ of North America North of Mexico. Bull. No. 3. Ohio Dept. of Agr.

Van Duzee, E. P. 1897. A Preliminary Review of the North American Delphacidæ. Bul. Buf. Soc. Nat. Sci. V, 225–261.

Van Duzee, E. P. 1908. Studies in North American Fulgoridæ. Proc. Acad. Nat. Sci. of Phila. December, 1907.

Westwood, J. O. 1840. Observations on the Genus Derbe of Fabricius. Trans. of the Linn. Soc. XIX, 1–21.

EXPLANATION OF PLATES.

Plate XXXII.

Fig. 1. Fore wing pad of Acanalonia sp.
Fig. 2. Hind "   " Acanalonia sp.
Fig. 3. Fore "   " Ormenis septentrionalis Spin.
Fig. 4. Hind "   " Ormenis septentironalis Spin.
Fig. 5. Fore "   " Amphiscepa bivittata Say.
Fig. 6. Hind "   " Amphiscepa bivittata Say.
Fig. 7. Fore "   " Phylloscelis atra Germ.
Fig. 8. Hind "   " Phylloscelis atra Germ.

Plate XXXIII.

Fig. 9. Fore wing of Poiocera fuliginosa Uhl.
Fig. 10. Hind "   Poiocera fuliginosa Uhl.
Fig. 11. Fore "   Cyrpoptus belfragei Stal.
Fig. 12. Hind "   Cyrpoptus belfragei Stal.
Fig. 13. Fore "   Ormenis septentrionalis Spin.
Fig. 14. Hind "   Ormenis septentrionalis Spin.
Fig. 15. Fore "   Amphiscepa bivittata Say.
Fig. 16. Hind "   Amphiscepa bivittata Say.
Fig. 17. Fore "   Acanalonia latifrons Walk.
Fig. 18. Fore "   Elidiptera opaca Say.
Fig. 19. Hind "   Elidiptera opaca Say.
Fig. 20. Fore "   Catonia sp.
Fig. 21. Hind "   Catonia sp.
Fig. 22. Fore "   Phylloscelis atra Germ.

PLATE XXXIV.

Fig. 23. Fore wing pad of Scolops sp.
Fig. 24. Hind   "   "   Scolops sp.
Fig. 25. Fore   "   "   Dictyophara sp.
Fig. 26. Hind   "   "   Dictyophara sp.
Fig. 27. Fore   "   "   Thionia simplex Germ.
Fig. 28. Hind   "   "   Thionia simplex Germ.

PLATE XXXV.

Fig. 29. Fore wing of Scolops perdix Uhl.
Fig. 30. Hind   "   Scolops perdix Uhl.
Fig. 31. Fore   "   Dictyophara florens Stal.
Fig. 32. Hind   "   Dictyophara florens Stal.
Fig. 33. Fore   "   Bruchomorpha oculata Newm.
Fig. 34. Hind   "   Bruchomorpha oculata Newm.
Fig. 35. Fore   "   Thionia bullata Say.
Fig. 36. Hind   "   Thionia bullata Say.
Fig. 37. Fore   "   Anotia sp.
Fig. 38. Hind   "   Anotia sp.
Fig. 39. Fore   "   Otiocerus coquebertii Kirby.
Fig. 40. Hind   "   Otiocerus coquebertii Kirby.
Fig. 41. Fore   "   Lamenia vulgaris Fitch.
Fig. 42. Hind   "   Lamenia vulgaris Fitch.

PLATE XXXVI.

Fig. 43. Fore wing pad of Stenocranus sp.
Fig. 44. Hind   "   "   Stenocranus sp.
Fig. 45. Fore   "   "   Stobæra tricarinata Say.
Fig. 46. Hind   "   "   Stobæra tricarinata Say.
Fig. 47. Fore   "   "   Myndus radicis Osb.
Fig. 48. Hind   "   "   Myndus radicis Osb.

PLATE XXXVII.

Fig. 49. Fore wing of Stenocranus lautus V. D.
Fig. 50. Hind   "   Stenocranus lautus V. D.
Fig. 51. Fore   "   Stobaera tricarinata Say.
Fig. 52. Hind   "   Stobaera tricarinata Say.
Fig. 53. Fore   "   Liburnia ornata Stal.
Fig. 54. Hind   "   Liburnia ornata Stal.
Fig. 55. Fore   "   Myndus sp.
Fig. 56. Hind   "   Myndus sp.
Fig. 57. Fore   "   Cixius sp.
Fig. 58. Fore   "   Oliarus 5-lineatus Say.
Fig. 59. Hind   "   Oliarus 5-lineatus Say.
Fig. 60. Fore   "   Bothriocera pro-signoretti.
Fig. 61. Hind   "   Bothriocera pro-signoretti.
Fig. 62. Fore   "   Œcleus decens Stal.
Fig. 63. Hind   "   Œcleus decens Stal.